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The Rev. Samuel Haughton, M. D., Fellow of Trinity College, Dublin, read the following paper:—

Notes on Animal Mechanics.

No. IV.—On the Muscular Anatomy of the Lion.

During the month of January last a fine Lion died of fever in the Zoological Gardens of this city, which had lived there for upwards of twelve years. I purchased his body for the use of the Anatomical School of Trinity College, in which the dissections were made which are used in this paper. I am indebted to Mr. Little, Medical Scholar of Trinity College, for the drawings from which two of the woodcuts were copied. The animal was in fine condition; both fat and muscle being well developed, which was to be expected, as he died after a short illness, which commenced on the 27th of December, 1863, and terminated fatally on the morning of the 12th of January, 1864. The Lion died of fever, and his chance of recovery was destroyed by the occurrence of three days' frost during his illness. We had no means of protecting him from the cold, and from the still more deadly damp that followed it during the thaw; and notwithstanding that he rallied for one day, under the influence of stimulants, he ultimately succumbed to the disease, and died with all the symptoms of a human being in fever. The only pathological appearances found after death were—a small circumscribed patch of consolidation in the right lung, and traces of chronic rheumatic arthritis in the right shoulder joint.

Part I.—Muscles of the Hip and Knee Joints.

1. *M. biceps femoris* weighs . . . . 27¾ oz.

This muscle is shown in Fig. 13, and forms a massive triangular sheet, having for its origin the highest point of the *tuber ischii;* and is inserted by strong fascia continuously from the middle of the femur covering the *vastus externus*, down the entire length of the outer side of the leg, as far as the *tendo Achillis,* round which it is fastened. The total length of the muscular fibres from *tuber ischii* to *tendo Achillis* is 22¼ inches, and from *tuber ischii* to highest insertion on femur 8¾ inches; and when the leg is extended, the third side of the muscular triangle is 17¼ inches. If the whole sheet of muscle be supposed of uniform thickness (which was nearly the case), the simultaneous contraction of all its fibres will draw the base of the muscular triangle towards its origin, parallel to itself; and the resultant of all the forces will lie in the bisector of the vertical angle. This resultant must therefore divide the base in the proportion of 22¼ to 8¾ inches. On making the calculation, it is found that the resultant intersects the base at a point 12·38 inches above the *tendo Achillis.* This point corresponds with the knee joint, and the effect of the whole muscle is the same as that of a single linear muscle from the *tuber ischii* to the top of the fibula.

Fig. 13.

2. *M. bicipiti accessorius.*[*] This muscle is represented by a long slender slip, intimately associated with the *biceps*, two feet in length, passing from the *os calcis* to the posterior point of the sacrum. It is shown at K, Fig. 14.

3. *M. agitator caudæ* weighs 6½ oz.

Origin from 1st, 2nd, and part of 3rd caudal vertebræ.

Insertion, by a long tendon into the outer side of the patella. This muscle is shown at C, Fig. 14. Its use is to wag the tail in a feline, not canine fashion; and also to secure the proper action of the patella preparatory to a spring. This seems to be the final cause of the violent agitation of the tail, vibrated from its first and second vertebræ, that forms so remarkable a characteristic of all the Felines. Considered from this mechanical point of view, the function of the *agitator caudæ* in the Lion is similar to that of the *rectus femoris* in the Ostrich.

4. *M. semitendinosus* (G, Fig. 14), weighs, . . . 10 oz.

Origin from *tuber ischii*.

Insertion, at upper point of trisection of the *tibia*.

5. *M. semimembranosus* (H, Fig. 14), weighs . . 26¼ oz.

Origin, from *tuber ischii*.

Insertion, into head of *tibia*, with a broad fascial insertion above and below the knee joint.[†]

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[*] It was suggested to me by Mr. Little that this muscle was the representative of the *plantaris;* and as I had found it to occur in the Dog and Badger, I was disposed to regard it as the representative of this muscle in the Carnivores. I am compelled to abandon this view from the observation of the fact, that in the Otter, in which animal also it is found, there is a well-marked *plantaris* occupying its usual position in the calf of the leg.

[†] For details, *vide* Fig. 15.

Fig. 14.

The *biceps* and *semimembranosus* act in planes parallel to the plane of motion of the knee joint, and from their mode of action must both have resultants passing through the junction of the thigh and leg, so that they must be regarded as principally extensors of the thigh, and not as flexors of the leg. The *semitendinosus*, on the other hand, acts as a flexor of the leg, and seems to abduct by the same angle that *gracilis* adducts; so that, considering that their weights are nearly equal, the resultant of *gracilis* and *semitendinosus* will also lie in the plane of motion of the knee joint.

6. *M. gracilis* weighs 9 oz.

7. *M.** *adductor magnus* weighs 27¼ oz.

Origin, inner border of *symphysis pubis*, and round the edge of the *M. obturator externus*, as far as the *tuber ischii.*

Insertion, along the *linea aspera*, through entire length of the back of the *femur*.

8. *M. adductor longus* weighs . . 2¾ oz.

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* The action of the *adductor magnus* is one of the most complicated in animal mechanics—for its origin is a curve, and its insertion a line, and these lie in different planes. Probably, in the Lion, half its muscular force is expended in simple extension of the femur, and the remaining portion, as in man, opposes the *glutæus medius*.

9. *M. pectinæus* passes over lesser trochanter, and weighs . ¾ oz.
10. *M. glutæus maximus* (B, Fig. 14) weighs . . . . . 3½ oz.
Origin, from last *sacral* vertebræ.
Insertion, into glutæal trochanteric ridge, for 2½ inches.
11. *M. glutæus medius* (D, Fig. 14) weighs . . . . . 14½ oz.

These *glutæi* divide the interval from the first caudal vertebra to the crest of the ilium, equally.

12. *M. glutæus minimus* (E, Fig. 14) weighs . . . . . 2½ oz.
Origin, from the dorsum of the ilium.
Insertion, at inner side of great trochanter.
13. *M. tensor vaginæ femoris** weighs . . . . 6½ oz.
14. *M. sartorius* weighs . . . . 11¾ oz.
15. *M. rectus femoris* (R, Fig. 14), weighs . . . . . 11 oz.
16. *MM. vasti et cruræus,* . . . . 32 oz.
17. *M. psoas parvus,* . . . . 2½ oz.
18. *M. Psoadiliacus,* . . . . 10¾ oz.
19. *M. quadratus femoris,* . . . . 1·58 oz.
Origin, from *tuber ischii.*
Insertion, into posterior intertrochanter ridge.
This muscle acts in the plane of the knee joint.
20. *M. iliocapsularis* (Q, Fig. 14), weighs . . . . . . 0·53 oz.
Origin, from *ilium,* behind the origin of *rectus femoris.*

Insertion, into the front of the *femur,* on the line below the great trochanter.

21. *M. pyriformis* weighs . . . . 2½ oz.
22. *M. obturator externus* weighs . . . . 2·60 oz.
23. *M. obturator internus* weighs . . . . 4 oz.

It has been well observed by Cuvier, that man is remarkably distinguished from the Quadrumans, by the preponderance of the *glutæus maximus* over the other *glutæi.* This is essentially a bipedal characteristic, as is shown in the following comparative Tables:—

Comparison of Glutæal Muscles in Man.

	Man.
1. Glutæus maximus,	53
2. Glutæus medius,	34
3. Glutæus minimus,	13
	100 parts.

Comparison of Glutæal Muscles in the Macaque, the Lion, and the Ostrich.

	Macaque.	Lion.	Ostrich
1. Glutæus maximus, Agitator caudæ, and Tensor vaginæ, combined,	28	49	76
2. Glutæus medius,	61	43	21
3. Glutæus minimus,	11	8	3
	100	100	100

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* The *tensor vaginæ* and *sartorius,* when acting in conjunction to flex the thigh, give a resultant in the plane of the knee joint.

Judged by the preceding comparative Tables, Man possesses the characteristic referred to, in a lesser degree than the Ostrich, in a greater degree than the Lion, and in a very much greater degree than the *Macacus Nemestrinus.* Strictly speaking, the Macaque is neither a biped like the Ostrich or Man, nor a quadruped like the Lion, but is a climber, and has relations of forces among the muscles of the posterior limb suited to that mode of locomotion.

The following figure, which shows the arrangement of the tendons at the inner side of the knee joint, was drawn from nature by my son, and will serve to explain any obscurity in the preceding descriptions of the muscles and their attachments:—

Fig. 15.

Part II.—Action of the Muscles of the Hip and Knee Joints.

The most important of the muscles just enumerated exert their action in extending or flexing the thigh upon the body in the plane of motion of the knee joint, which is parallel to the brim of the acetabulum in ordinary positions of the leg.

They may be classed as follows:—

1. *Extensors of Thigh.*

	Ozs.
1. Biceps femoris,	27·75
2. Semitendinosus,	10·00
3. Semimembranosus,	26·25
4. Gracilis,	9·00
5. Adducter magnus,*	13·62 ?
6. Adductor longus,	2·75
7. Quadratus femoris,	1·58
Total moment of Extension of Thigh,	90·95 oz.

2. *Flexors of Thigh.*

	Ozs.
1. Tensor vaginæ femoris,	6·50
2. Sartorius,	11·75
3. Psoadiliacus,	10·75
Total moment of Flexion of Thigh,	29·00 oz.

From the preceding it appears that the total moment of extension exceeds that of flexion in the proportion of 91 to 29, nearly, or more than three times.

Let us now suppose the thigh flexed on the body at an angle of 45°, as it would be preparatory to a spring, and consider the action of the remaining muscles of the hip joint. They all tend to turn the femur in planes perpendicular to the plane already considered, and which all pass through the axis perpendicular to the brim of the acetabulum.

I examined carefully the azimuths of the planes of motion of these muscles on the rim of the acetabulum, in the position of the thigh described, and found them to be as follows, counting from right to left, on the left leg of the Lion:—

Rotators of Thigh.

Muscles.	Azimuth.	Moment. Ozs.
1. Obturator externus,	0°	2·60
2. Pectinæus,	60	0·75
3. Ilio capsularis,	149	0·53
4. Glutæus minimus,	167	2·50
5. Glutæus medius,	193	14·50
6. Pyriformis,	266	2·50
7. Glutæus maximus,	266	3·50
8. Obturator internus,	277	4·00
9. Agitator caudæ,	277	6·50
10. Adductor magnus,	360	13·62 ?
Total moment of Muscles rotating the Thigh,		51·00 oz.

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* Half the force of the *adductor magnus* is here supposed to act in the plane of motion of the knee joint.

It is probable that the muscles here given as rotators never act together in one leg only, for the Lion never attempts to stand on one leg; but it may be useful to calculate what would be the direction and magnitude of their total resultant. Assuming the plane of the component couple X to be that of the muscles *obturator externus* and *adductor magnus*, we find—

$$X = 16 \cdot 22 + 0 \cdot 75 \cos 60^\circ - 0 \cdot 53 \cos 31^\circ - 17 \cos 13^\circ - 6 \cos 86^\circ + 10 \cdot 5 \cos 83^\circ = 0 \cdot 29 \text{ oz.}$$

$$Y = 0 + 0 \cdot 75 \sin 60^\circ + 0 \cdot 53 \sin 31^\circ - 12 \sin 13^\circ - 6 \sin 86^\circ - 10 \cdot 5 \sin 83^\circ = - 18 \cdot 18 \text{ oz.}$$

$$\frac{Y}{X} = - \tan (89^\circ\ 5')$$

$$\sqrt{Y^2 + X^2} = 18 \cdot 18 \text{ oz.}$$

The resultant moment of all the muscles causing rotation lies, therefore, in a plane nearly perpendicular to the plane of the *obturator externus*, and is represented by a weight of lion flesh of 18·18 oz. acting towards the body.

When the Lion crouches on his haunches, with his feet somewhat apart, and knees approximated, acting as fulcra, the origins and insertions of the rotator muscles are converted, and they all become available to assist in his spring, which is thus aided by the propulsion of the haunch upwards by the joint action of the rotator muscles of both legs; and his body is at the same time propelled forward by the action of all the extensors of the thigh, leg, and foot of both sides.

PART III.—MUSCLES OF SHOULDER AND ELBOW JOINTS.

1. *M. pectoralis major*, ... 34¼ oz.
Origin, from whole length of sternum.
Insertion, into whole length of pectoral ridge of humerus, with a slip joining the *deltoido-trapezius* as it passes on to be inserted in the radius.

2. *M. pectoralis minor*, ... 7¾ oz.

8. *M. deltoido-trapezius*, ... 15¾ oz.
This conjoined muscle forms a large sheet, covering the scapula and head of humerus, and flowing freely over them in the rapid actions of the arm; it is inserted partly into the moveable clavicle, and partly into the inner side of the ulna, one inch below the elbow joint.

4. *M. deltoideus proprius*, ... 4¾ oz.
Origin, anterior third of spine of scapula.
Insertion, deltoid ridge on outer side of humerus.

5. *M. cleido-mastoideus*, ... 4¼ oz.
This muscle has a double origin, from the mastoid process and from the transverse process of the dentatus; it is inserted into the floating clavicle.

6. *M. levator anguli scapulæ,*	2¼ oz.

Origin, from the fascia in the upper part of side of neck.

Insertion, into the anterior extremity of the vertebral edge of the scapula.

7. *M. serratus magnus,*	20¾ oz.
8. *M. rhomboideus major,*	7¾ oz.

This muscle is inserted into the vertebral edge of the scapula, and rotates it in a direction opposite to that of the *serratus magnus.*

9. *M. rhomboideus minor,*	½ oz.

This muscle, though rudimentary, is distinct.

10. *M. supraspinatus,*	14½ oz.
11. *M. infraspinatus,*	13 oz.
12. *M. subscapularis,*	14¾ oz.
13. *M. triceps,*	43½ oz.
14. *M. teres major,*	9½ oz.

Origin, whole posterior edge of the scapula.

Insertion, into the middle third of the humerus, by means of a flat tendon.

15. *M. latissimus dorsi,*	25½ oz.

This vast sheet of muscle is inserted into the middle of the tendon of the *teres major,* at four inches distant from the humerus.

16. *M. biceps,*	8 oz.
17. *M. brachialis externus,*	4 oz.
18. *M. coraco-brachialis,*	¼ oz.

This muscle is rudimentary, but regular, and possesses a long tendon, also rudimentary.

PART IV.—MUSCLES OF MASTICATION.

1. *M. masseter.*

This muscle is divided into two distinct portions; one external, with fan-shaped fibres radiating from the angle of the jaw, and more or less horizontal; and the other internal, with vertical fibres, arising from the whole internal surface of the zygoma, and inserted into the masseteric cavity of the ramus.

The external, or horizontal portion, weighs	11 oz.
The internal, or vertical portion	6½

The second portion of the *masseter* is a direct closer of the mouth.

2. *M. temporalis.*

The temporal muscle is also divided into two; one superficial, arising partly from the superficial fascia, and partly from the margin of the temporal fossa, behind the ear, and from the back of the orbit; this portion, in passing downwards to the coronoid process, becomes blended with the internal portion of the *masseter* on the outer side, and with the second portion of the temporal on the inner side.*

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* This superficial portion of the temporal muscle is well seen in the Otter, in which animal it is better separated from the masseter, and from the true temporal, than in the Lion.

The second part of the temporal muscle has the usual origin and insertion.

The superficial temporal weighs	6 oz.
The true temporal,	16½ oz.

The vertical fibres of the *masseter* close the jaw directly without producing any pressure on the joint; but the fan-shaped fibres of this muscle cause a powerful pressure on the condyle of the lower jaw, forcing it backwards into its socket. Such seems to be also the function of the superficial fibres of the temporal muscle, which press the condyle into its socket, as well as close the mouth. This pressure seems to be necessary, in consequence of the habit the Lion has of carrying his prey in his mouth for a long time before he devours it; for the weight so carried would inevitably dislocate the jaw, if there were not a special provision made in the action of the masticating muscles to guard against it.

3. *MM. pterygoidei.*

The first part of these (*externus*) weighs . . . . ¾ oz.

Its origin is the posterior portion of the pterygoid plate, and it is inserted into the *masseter* muscle at the angle of the jaw. Its action is to draw the fibres of the masseter forward, and give them a longer leverage.

The second portion of the pterygoid muscle (internus) weighs 2 oz.

It arises from the anterior portion of the pterygoid plate, with an extensive origin also from the floor of the orbit, and is inserted two inches from the angle of the jaw.

Its action is to close the jaw, and draw it forward.

4. *M. digastricus,* . . . . 2½ oz.

This is the proper muscle for opening the mouth in all the carnivora.

Its origin is the mastoid process.

Its insertion is into a line 3½ inches in length backwards from the symphysis of the jaw, along the mylo-hyoid ridge.

The Rev. Samuel Haughton, M. D., Fellow of Trinity College, Dublin, read the following Paper :—

Notes on Animal Mechanics.

No. V.—The Muscular Anatomy of the Seal.*

The muscular anatomy of the Seal differs in many important particulars from that of the other Carnivores; and this difference seems to be occasioned principally by its aquatic habits, which render it better adapted for locomotion in the water than on dry land. In the anterior

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* The drawings from which the woodcuts were made were taken from nature by my son.